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OBSERVATIONS OF SNOW DUNES ON LAKE ERIE[1]

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ABSTRACT. Various snow dune forms were observed and photographed on frozen Lake Erie at Marblehead, Ohio, in January 1982. The dune field contained several dune types. The barchan was the most common form; seif and triangular dunes were also sighted. Conditions necessary for dune formation included winds from a constant direction and a flat ice surface. Dunes were not seen on the ice where pressure ridges existed.

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INTRODUCTION

Depositional features formed in sand have been studied extensively in recent years (Bagnold 1941, Lancaster 1980, Worrall 1974). However, few articles have been published on forms produced by blowing snow. There appears to be a similarity between the sand and snow forms of eolian deposition. An early study by Cornish (1914) attempted to describe these similarities. He attributed this likeness in form to atmospheric eddy structures. More recently, Langham (1981), Kind (1981), and Schmidt (1982) have reviewed the literature on snow deposition, drifts, and snow forms. Doumani (1967) and Rikhter (1945) outlined the classification of snow drift forms and described the factors causing variation in these features. Rikhter established 3 categories: barchans, wave-like configurations, and other forms. Many of the references pertaining to snow drift forms have been related to studies conducted in the Antarctic (Moss 1938) while few have dealt with snow forms on the Great Lakes (Hannes and Hannes 1982).

OBSERVATIONS AND DISCUSSION

METEOROLOGICAL CONDITIONS. Weather data from the Marblehead Coast Guard Station (41°32′30″N, 82°43′30″W) were obtained (table 1). A light snow covered the ice on Lake Erie on 25 January 1982. Winds were generally from the north, but no dunes were formed on that day. By the afternoon and late evening of 26 January (1100–2300), the winds had shifted to the west-southwest and southwest. Air temperatures at this time were still below freezing. However, no dunes were observed on 26 January. Figs. 1, 2, and 3 were taken in the mid-afternoon of 27 January between 1300 and 1430 LST. Early on 27 January (0500), the winds had shifted to the south. This southerly flow persisted approximately 16 hours before shifting to the south-southwest. The wind speed varied from 4.6 to 7.7 m/sec throughout the morning and early afternoon, generally higher than the previous day. Air temperatures ranged from −3.9 to −2.2 C during the afternoon hours. The snow dunes formed when the wind was constant in direction. This is in agreement with the conditions for the formation of barchan dunes in sand (Bagnold 1941) and ice (Moss 1938). On the evening of 27 January at 2300, the winds generally increased in speed and shifted to the south-southwest. This continued through 28 January. The higher velocities coupled with increasing air temperatures caused the ice to break up on 28 January, destroying the snow dune field.

LAKE ERIE SNOW DUNES. According to Bagnold (1941), windblown deposits include drifts and true dunes. Unlike the more common snow drifts of the northern Ohio area, dunes can exist independently

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TABLE 1

Meteorological data for 26, 27, and 28 January 1982, at Marblehead Coast Guard Station.

Local Standard Time	Wind Direction	Wind Speed (m/sec)	Air Temperature (C)
26 January 1982			
0100	W	4.1	−13.9
0300	W	4.1	−13.9
0500	WNW	4.6	−12.2
0700	WNW	5.6	−11.1
0900	W	3.6	−9.4
1100	WSW	2.5	−8.9
1300	WSW	4.1	−6.7
1500	WSW	4.1	−6.7
1700	WSW	5.1	−7.2
1900	SW	4.6	−11.1
2100	SW	5.6	−12.2
2300	SW	5.1	−13.3
27 January 1982			
0100	SW	5.1	−14.4
0300	SW	5.1	−14.4
0500	S	4.6	−11.1
0700	----------	Missing	---------
0900	S	7.7	−8.9
1100	S	7.7	−6.1
1300	S	6.6	−3.9
1500	S	6.6	−2.2
1700	S	7.7	−2.2
1900	S	5.1	−2.8
2100	S	5.1	−2.8
2300	SSW	6.1	0.0
28 January 1982			
0100	SW	7.7	1.1
0300	SW	12.8	3.3
0500	SW	5.6	3.3
0700	SW	10.8	3.3
0900	SW	8.2	3.3
1100	SW	6.1	2.2
1300	WSW	11.8	2.8
1500	WSW	10.2	2.8
1700	W	10.2	1.1
1900	W	10.2	−1.7
2100	WSW	5.1	−3.3
2300	W	4.6	−5.0

of obstacles such as rocks, vegetation, and buildings. On 27 January 1982, snow dunes were observed and photographed on Lake Erie at Marblehead, Ohio. The photographs were taken on the headland which forms the easternmost portion of the Marblehead Peninsula (fig. 4). The views are generally looking in southerly and southeasterly directions towards the mouth of Sandusky Bay. Several dunes were seen on the frozen lake, as shown in figs. 1, 2, and 3, including barchans, seif dunes, interlocking barchans, triangular dunes, and irregular forms. The dune field covered an area of approximately 650 ha on Lake Erie and extended into Sandusky Bay.

FIGURE 1. Snow dune field on Lake Erie looking south-southeast towards the mouth of Sandusky Bay.

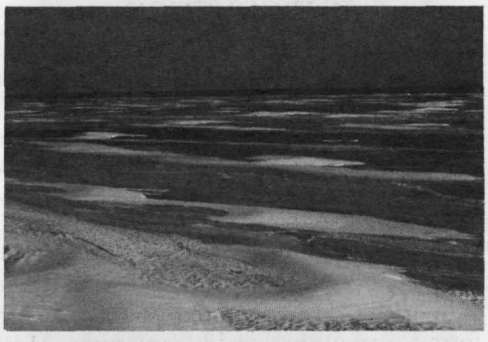

FIGURE 2. Barchan dunes.

FIGURE 3. Seif and other dune forms.

While being photographed, the dunes were being built by saltation, the process by which snow particles are picked up and transported by the wind with intermittent contact with the ice. This is best observed in fig. 1. According to Kind (1981), saltation is generally confined to a thin or shallow layer above the surface. Deposition of snow is then brought about by boundary layer turbulence (Langham 1981).

Perhaps the most common form observed in the dune field was the barchan, or crescent-shaped feature with tips or horns pointing downwind (fig. 2). According to Doumani (1967), the shapes of snow barchans can be quite variable. Generally, snow barchans are less crescentic in shape than sand dunes. The estimated size of the Lake Erie barchans was from 2.7 to 3.6 m in length, 1.8 to 2.4 m in width (or from horn–to–horn), and less than 0.6 m in height. Also visible is the lee face of the barchan (fig. 2). Doumani (1967) suggests that snow dunes differ from sand dunes in that the latter have a true slip face whereas the former do not. There is very little slippage on the lee side of a snow dune, and therefore no true slip face exists. This lack of a slip face suggests that the migration of barchan snow forms is different than that of sand.

Barchan dunes are excellent indicators of wind direction since their horns point downwind. For example, fig. 2 is looking towards the southeast. The winds are blowing from the south (or right side); therefore, the horns are on the left sides of the barchans. In fig. 1, south is at the upper right corner; the snow appears to be saltating diagonally across the photograph.

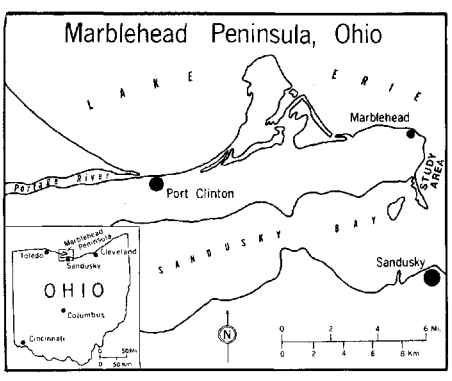

FIGURE 4. Location of the study area in northern Ohio.

Triangular dune forms also appear in the photographs, particularly in fig. 1. They were generally smaller in size than the barchans. Triangular forms may represent the erosion of existing barchans or possibly the formation of new barchans. Enough observations were not taken to support or refute this possible relationship to barchans.

Seif forms were also visible near the shoreline where the topography likely caused a multidirectional wind pattern (fig. 3). As described by Bagnold (1941) and reaffirmed by Lancaster (1980), seif sand dunes evolve over time through the transformation of barchan dunes. The horizontally trending snow dune just below the center of fig. 3 illustrates the seif form diagramed in Lancaster's article. It appears as 2 modified barchans joined by the elongation of one of the horns of the upwind dune. Apparently, snow seifs conform to Bagnold's hypothesis on their formation as a variation in the wind field operates on barchan forms.

No dunes formed along the northern shore of the Marblehead Peninsula. Small pressure ridges, ice jams, and other surface irregularities were noted in the areas free of dune forms. Therefore, the dunes developed only where the ice surface was extremely flat. It is also interesting to report that no dunes were created on a large, flat, unvegetated exposure of limestone rock less than 1.0 km west of the dune field. Perhaps the topography of the Peninsula as well as the trees surrounding the limestone exposure modified the wind flow patterns. The physical nature of the flat surface — ice versus rock — may also be a factor.

Dunes formed by blowing snow are therefore generally similar to those of blowing sand. They are ephemeral features requiring very specific snow properties, surface conditions, and wind characteristics. Where the ice was smooth at the

easternmost tip of the Marblehead Peninsula, winds blowing from the south created the dune field.

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